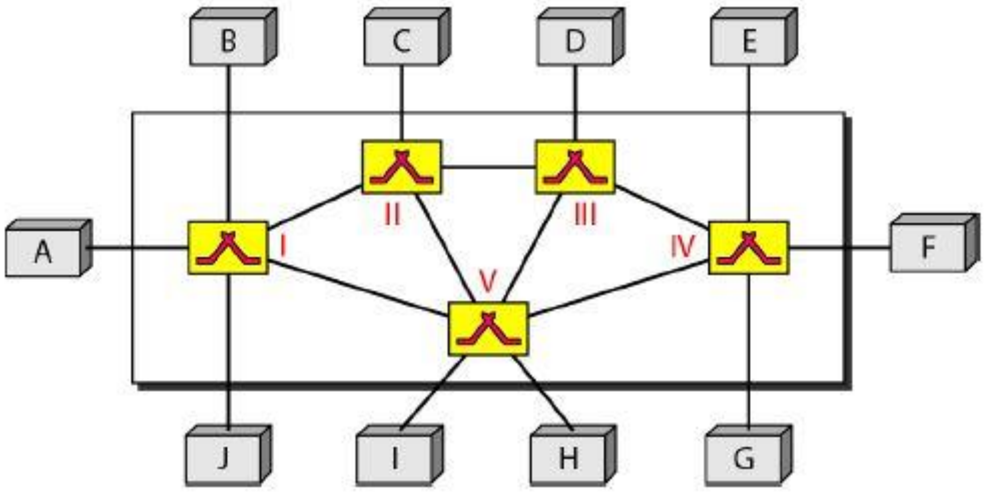
SWITCHING

A network is a set of connected devices. Whenever we have multiple devices, we have to connect them to make one-to-one communication possible.

- One solution is to make a point-to-point connection between each pair of devices (a mesh topology) or between a central device and every other device (a star topology). These methods, however, are impractical and wasteful when applied to very large networks.

- A better solution is switching. A switched network consists of a series of interlinked nodes, called switches. Switches are devices capable of creating temporary connections between two or more devices linked to the switch.

Switched network

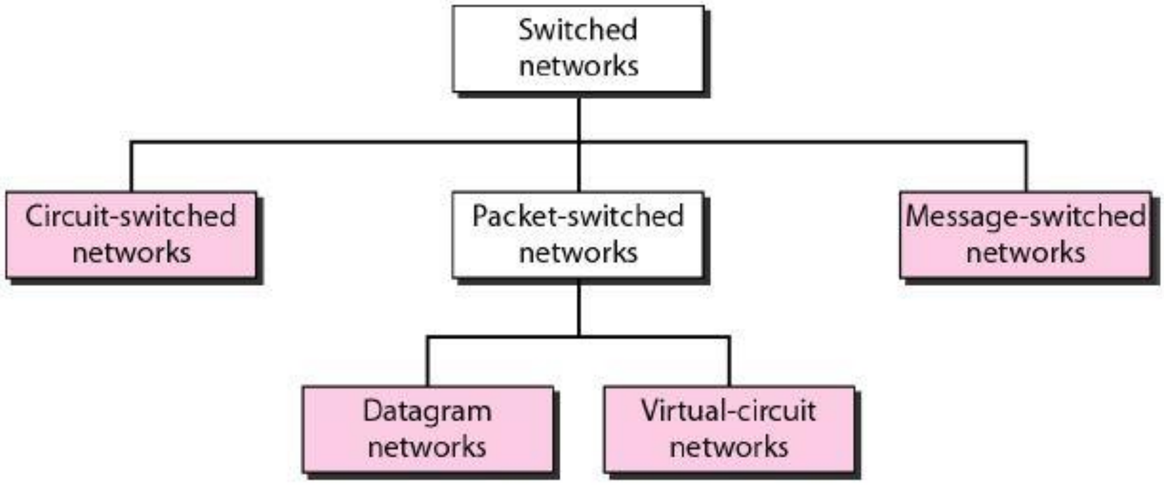


Types of Switched Networks

We can then divide today's networks into three broad categories:

1. Circuit-switched networks,
2. Packet-switched networks, and
3. Message-switched.

Packet-switched networks can further be divided into two subcategories-virtual-circuit networks and datagram networks.



1. **Circuit Switching**:
   Circuit switching is a communication method used in telecommunications networks, particularly in traditional telephone networks.

   When two devices want to communicate using circuit switching, a dedicated path or circuit is established between them.

   Here's a more detailed explanation:
   - **Connection Establishment**:
     - Before data transmission begins, a process called call setup is initiated. During call setup, signaling protocols are used to negotiate and establish the circuit between the source and destination devices.

    - Call setup involves several steps, including dialing a phone number, signaling between network elements (such as switches), and allocating resources (such as bandwidth) for the circuit.
    - Once the circuit is established, it remains dedicated to the communication session until the call ends. This means the bandwidth is continuously reserved for the two communicating devices, even if there are periods of silence or no data transmission.
- **Bandwidth Allocation**:
    - Circuit switching guarantees a fixed bandwidth for the duration of the communication session. This dedicated bandwidth ensures a consistent quality of service (QoS) and low latency for real-time applications like voice calls.
    - The allocated bandwidth remains constant regardless of whether data is actively being transmitted. This static allocation distinguishes circuit switching from packet switching, where bandwidth is shared dynamically among multiple packets.
-

- **Examples**:
  - Traditional telephone networks use circuit switching for voice calls. When you make a phone call, a dedicated circuit is established between your phone and the recipient's phone until you hang up.
  - Circuit-switched networks are also used in specialized applications such as leased lines for data communication between two locations, where dedicated bandwidth is required.

2. **Packet Switching**:

   Packet switching is a fundamental technique used in computer networks, including the Internet.
   Unlike circuit switching, where a dedicated path is established, packet switching breaks data into smaller packets that are independently routed across the network. Here's a detailed look at packet switching:

- **Packetization**:
  - Data is segmented into smaller units called packets. Each packet contains a portion of the original data, along with header information that includes source and destination addresses.

  - Packetization allows large data streams to be efficiently transmitted over the network by breaking them into manageable chunks.
- **Routing and Forwarding**:
  - Each packet is routed independently based on its destination address. Routers and switches examine the packet headers to determine the best path through the network.
  - Packet-switched networks use routing protocols (e.g., OSPF, BGP) to dynamically update routing tables and adapt to network changes, such as link failures or congestion.
- **Dynamic Resource Allocation**:
  - Packet switching enables dynamic resource allocation, where network resources (such as bandwidth) are shared among multiple packets and users.
  - Bandwidth is allocated on a per-packet basis, allowing for efficient utilization of network resources and scalability.

- **Examples**:
    - The Internet is a prime example of a packet-switched network.
    - When you send an email, browse a website, or stream video, data is broken into packets that traverse various routers and switches before reaching their destination.
    - Other packet-switched technologies include Ethernet LANs and WANs, where data packets are forwarded based on MAC addresses within local networks.

STRUCTURE OF A SWITCH

We use switches in circuit-switched and packet switched networks. In this section, we discuss the structures of the switches used in each type of network.

Topics discussed in this section:

- Structure of Circuit Switches
- Structure of Packet Switches

Structure of Circuit Switches

Circuit switching today can use either of two technologies:

the space-division switch or the time-division switch.

Space-Division Switch

In space-division switching, the paths in the circuit are separated from one another spatially.

This technology was originally designed for use in analog networks but is used currently in both analog and digital networks.

Time-Division Switch

Time-division switching uses time-division multiplexing (TDM) inside a switch. The most popular technology is called the time-slot interchange (TSI).

Crossbar Switch

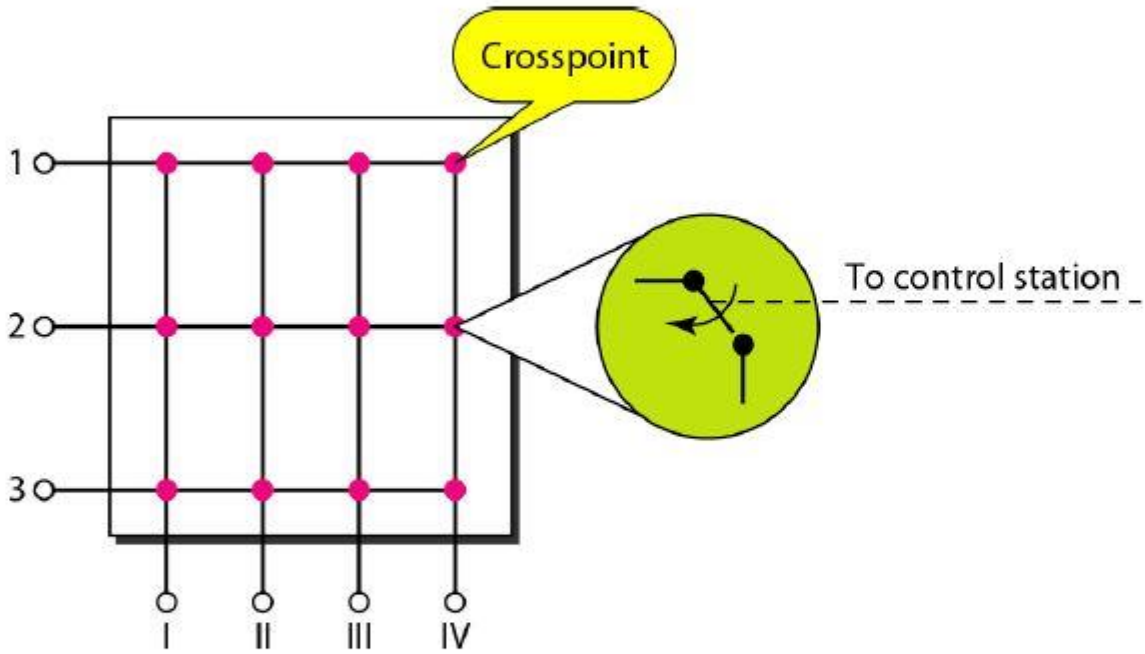
A crossbar switch connects n inputs to m outputs in a grid, using electronic microswitches (transistors) at each crosspoint.

The major limitation of this design is the number of crosspoints required.

To connect n inputs to m outputs using a crossbar switch requires n x m crosspoints.

Such a switch is also inefficient because statistics show that, in practice, fewer than 25 percent of the crosspoints are in use at any given time. The rest are idle.

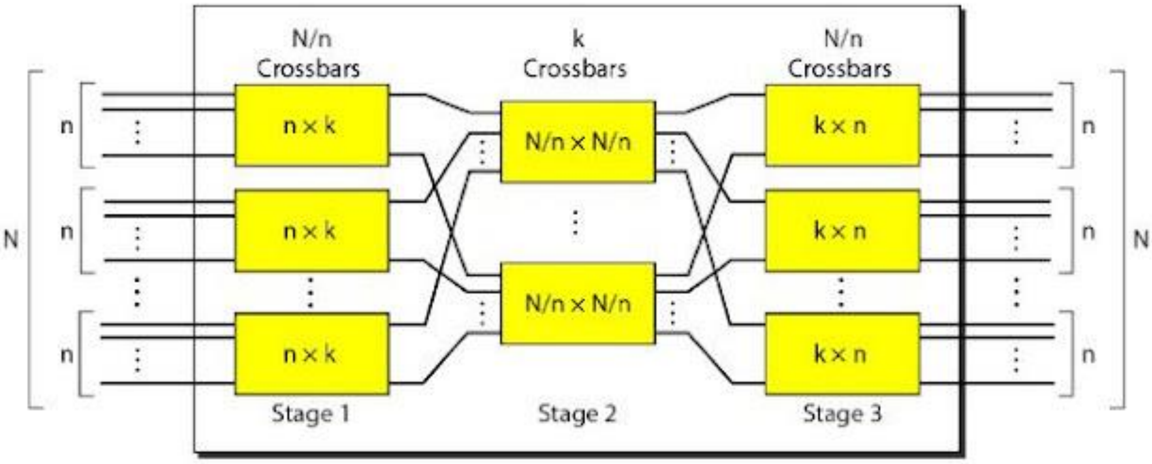
Crossbar switch with three inputs and four outputs



Multistage Switch

- The solution to the limitations of the crossbar switch is the multistage switch, which combines crossbar switches in several (normally three) stages.
- In a single crossbar switch, only one row or column (one path) is active for any connection. So we need N x N crosspoints.
- If we can allow multiple paths inside the switch, we can decrease the number of crosspoints. Each crosspoint in the middle stage can be accessed by multiple crosspoints in the first or third stage.

Multistage switch



Note
In a three-stage switch, the total number of crosspoints is
2kN + k(N/n)2
which is much smaller than the number of crosspoints in a single-stage switch (N2).

Drawback

- The multistage switch has one drawback-blocking during periods of heavy traffic:
- Blocking refers to times when one input cannot be connected to an output because there is no path available between them-all the possible intermediate switches are occupied.
- In a single-stage switch, blocking does not occur because every combination of input and output has its own crosspoint; there is always a path.

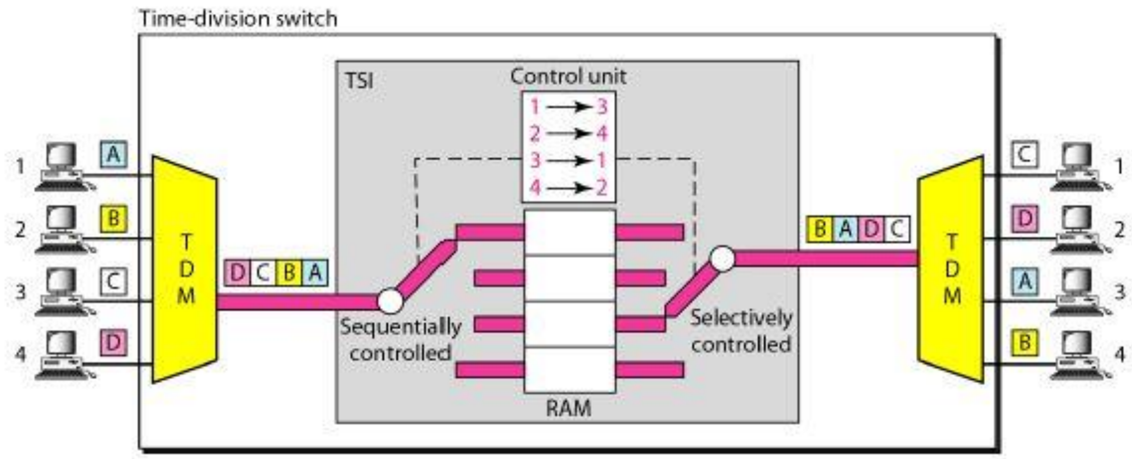
- Clos investigated the condition of nonblocking in multistage switches and came up with the following formula. In a nonblocking switch, the number of middle-stage switches must be at least 2n - 1. In other words, we need to have k >2n - 1.

Time-Division Switch

- A multistage switch that uses the Clos criteria and a minimum number of crosspoints still requires a huge number of crosspoints.
- For example, to have a 100,000 input/output switch, we need something close to 200 million crosspoints (instead of 10 billion). The number can be reduced if we accept blocking.
- Time-division switching uses time-division multiplexing (TDM) inside a switch. The most popular technology is called the timeslot interchange (TSI).

Time-Slot Interchange

- A TSI consisting of random access memory (RAM) with several memory locations.
- The size of each location is the same as the size of a single time slot. The number of locations is the same as the number of inputs.
- The RAM fills up with incoming data from time slots in the order received.Slots are then sent out in an order based on the decisions of a control unit.



Time- and Space-Division

Switch Combinations

We combine space-division and time-division technologies to take advantage of the best of both. Combining the two results in switches that are optimized both physically (the number of crosspoints) and temporally (the amount of delay). Multistage switches of this sort can be designed as time-space-time (TST) switch.

Time-space-time switch